# NATIONAL BUREAU OF STANDARDS REPORT

No 6605

on

Interlaboratory Intercomparisons

of

32-Watt T10 Cool-White Circline Lamps

Photometry and Colorimetry Section
Optics and Metrology Division

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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# NATIONAL BUREAU OF STANDARDS REPORT

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# Interlaboratory Intercomparisons of 32-Watt T10 Cool-White Circline Lamps

by Velma I. Burns

## Abstract

A group of ten 32-watt T10 cool-white rapid-start circline fluorescent lamps were measured by each of six laboratories. Luminous flux, current, voltage, and watts were measured while holding the line voltage constant at 147 volts across the lamps in series with a reactor having 235 ohms impedance and 7-8% power factor. The results of the measurements made by the individual laboratories and an analysis of the results are given in this report.

## I. Introduction

This intercomparison was undertaken to determine the uniformity of measurements on 32-watt T10 cool-white rapid-start circline fluorescent lamps made at the participating laboratories. The laboratories participating and the order of reading are as follows:

I. Sylvania Electric Products
II. Champion Lamps Works
III. Westinghouse
IV. General Electric
V. Interlectric
VI. Duro Test

The order in which the laboratories made their measurements was chosen to reduce shipment of the lamps as much as possible. Each laboratory followed its own customary procedure in making the measurements. All laboratories held the line voltage constant at 147 volts and used circuits having 235 ohms impedance at 7-8% power factor. Two of the laboratories made additional sets of measurements while holding the power constant at 32 watts. One laboratory reported measurements made while holding the current constant at 0.435 ampere.

## II. Results of Measurements

The results reported are given in tables 1 through 5. The average reported for each lamp and for each laboratory and the difference $\Delta$ between the average for each laboratory and the average of all laboratories for all lamps are also given in the tables.

Table 1

Luminous Flux in Lumens

Lamps operated at 147 line volts

| Lamp No. | Syl. | Champ. | West. | G.E. | Interl. | Duro. | Av. |
|---|---|---|---|---|---|---|---|
| 1 | 1670 | 1644 | 1598 | 1630 | 1582 | 1608 | 1622.0 |
| 2 | 1682 | 1672 | 1595 | 1648 | 1632 | 1646 | 1645.8 |
| 3 | 1656 | 1662 | 1616 | 1634 | 1615 | 1647 | 1638.3 |
| 4 | 1666 | 1656 | 1586 | 1626 | 1607 | 1618 | 1626.5 |
| 5 | 1658 | 1674 | 1619 | 1662 | 1628 | 1661 | 1650.3 |
| 6 | 1646 | 1654 | 1602 | 1625 | 1607 | 1612 | 1624.3 |
| 7 | 1626 | 1660 | 1624 | 1632 | 1605 | 1617 | 1627.3 |
| 8 | 1682 | 1672 | 1611 | 1639 | 1617 | 1642 | 1643.8 |
| 9 | 1654 | 1666 | 1590 | 1652 | 1627 | 1646 | 1639.2 |
| 10 | 1660 | 1672 | 1614 | 1649 | 1627 | 1647 | 1644.8 |
| Av. | 1660.0 | 1663.2 | 1605.5 | 1639.7 | 1614.7 | 1634.4 | 1636.2 |
| △ | +23.8 | +27.0 | -20.7 | +3.5 | -21.5 | -1.8 | |

Table 2

Current in Amperes

Lamps operated at 147 line volts

| Lamp No. | Syl. | Champ. | West. | G.E. | Interl. | Duro. | Av. |
|---|---|---|---|---|---|---|---|
| 1 | .438 | .435 | .422 | .434 | .423 | .418 | .4283 |
| 2 | .432 | .436 | .428 | .441 | .430 | .426 | .4322 |
| 3 | .432 | .431 | .420 | .431 | .427 | .421 | .4270 |
| 4 | .432 | .432 | .418 | .433 | .428 | .418 | .4268 |
| 5 | .434 | .434 | .426 | .440 | .427 | .424 | .4308 |
| 6 | .429 | .433 | .422 | .432 | .418 | .415 | .4248 |
| 7 | .437 | .435 | .428 | .439 | .423 | .424 | .4310 |
| 8 | .435 | .430 | .418 | .432 | .425 | .418 | .4263 |
| 9 | .431 | .431 | .415 | .435 | .425 | .422 | .4265 |
| 10 | .432 | .433 | .413 | .434 | .427 | .422 | .4268 |
| Av. | .4332 | .4330 | .4210 | .4351 | .4253 | .4208 | .4281 |
| △ | +.0051 | +.0049 | -.0071 | +.0070 | +.0028 | -.0073 | |

Table 3

Lamp Volts

Lamps operated at 147 line volts

| Lamp No. | Syl. | Champ. | West. | G.E. | Interl. | Duro. | Av. |
|---|---|---|---|---|---|---|---|
| 1 | 80.0 | 81.6 | 85.0 | 84.9 | 84.3 | 84.6 | 83.40 |
| 2 | 81.0 | 81.4 | 83.8 | 83.2 | 83.7 | 83.4 | 82.75 |
| 3 | 81.5 | 82.0 | 85.3 | 83.3 | 84.7 | 84.1 | 83.48 |
| 4 | 80.5 | 81.5 | 86.2 | 85.5 | 84.3 | 85.0 | 83.83 |
| 5 | 80.0 | 81.5 | 83.5 | 83.2 | 84.0 | 83.5 | 82.62 |
| 6 | 83.0 | 81.6 | 85.0 | 85.7 | 86.7 | 86.0 | 84.67 |
| 7 | 80.2 | 81.5 | 83.2 | 84.2 | 85.0 | 83.7 | 82.97 |
| 8 | 81.0 | 81.9 | 85.8 | 84.9 | 84.7 | 84.5 | 82.80 |
| 9 | 81.5 | 82.0 | 86.5 | 84.7 | 85.0 | 83.9 | 83.93 |
| 10 | 81.0 | 81.6 | 86.8 | 85.1 | 85.3 | 84.0 | 83.97 |
| Av. | 80.97 | 81.66 | 85.11 | 84.47 | 84.77 | 84.27 | 83.54 |
| $\Delta$ | -2.57 | -1.88 | +1.57 | +.93 | +1.23 | +.73 | |

Table 4

Lamp Watts

Lamps operated at 147 line volts

| Lamp No. | Syl. | Champ. | West. | G.E. | Interl. | Duro. | Av. |
|---|---|---|---|---|---|---|---|
| 1 | 32.0 | 32.5 | 31.6 | 33.3 | 33.3 | 32.4 | 32.52 |
| 2 | 32.0 | 32.3 | 31.8 | 33.2 | 34 | 32.3 | 32.60 |
| 3 | 32.1 | 32.3 | 31.8 | 33.2 | 34 | 32.2 | 32.60 |
| 4 | 31.9 | 32.0 | 31.9 | 33.4 | 34 | 32.2 | 32.57 |
| 5 | 31.9 | 32.1 | 31.6 | 33.1 | 34 | 32.2 | 32.48 |
| 6 | 32.2 | 32.3 | 31.8 | 33.5 | 34 | 32.4 | 32.70 |
| 7 | 32.2 | 32.4 | 31.8 | 33.4 | 34 | 32.4 | 32.70 |
| 8 | 32.2 | 32.1 | 31.9 | 33.1 | 34 | 32.1 | 32.57 |
| 9 | 32.0 | 32.5 | 31.8 | 33.2 | 34 | 32.1 | 32.60 |
| 10 | 32.0 | 32.1 | 31.6 | 33.2 | 34 | 32.1 | 32.50 |
| Av. | 32.05 | 32.26 | 31.76 | 33.26 | 33.93 | 32.24 | 32.58 |
| $\Delta$ | -.53 | -.32 | -.82 | +.68 | +1.35 | -.34 | |

Table 5

Lamps operated at 32 watts

| Lamp No. | Lumens | | Amperes | | Volts | |
|---|---|---|---|---|---|---|
| | West. | Duro | West. | Duro | West. | Duro |
| 1 | 1607 | 1590 | .426 | .412 | 84.7 | 85.2 |
| 2 | 1601 | 1635 | .427 | .422 | 83.8 | 83.5 |
| 3 | 1624 | 1640 | .424 | .418 | 85.2 | 84.3 |
| 4 | 1597 | 1602 | .422 | .412 | 85.2 | 85.4 |
| 5 | 1639 | 1653 | .433 | .422 | 82.8 | 83.5 |
| 6 | 1611 | 1591 | .427 | .408 | 84.5 | 86.2 |
| 7 | 1635 | 1602 | .433 | .419 | 83.3 | 83.9 |
| 8 | 1618 | 1642 | .421 | .417 | 85.8 | 84.3 |
| 9 | 1600 | 1646 | .417 | .422 | 86.2 | 83.8 |
| 10 | 1630 | 1643 | .420 | .421 | 86.2 | 84.0 |
| | 1616 | 1624 | .425 | .417 | 84.8 | 84.4 |

## III. Analysis of the Results

An analysis of the results of the measurements made at 147 line volts has been made following a modification of the method described by W. J. Youden[1] in the following way:

[1] Graphical Diagnosis of Interlaboratory Test Results, Industrial Quality Control, Vol. XV, No. 11, May 1959.

The difference between lumens measured by one laboratory for lamp No. 1 and the average of the lumens measured by all laboratories for lamp No. 1 was obtained and used as the x-coordinate to plot a point. The y-coordinate was obtained by taking the difference between the lumens measured for lamp No. 2 by the same laboratory and the average of the lumens measured by all laboratories for lamp No. 2. Thus each laboratory provided a difference for lamp No. 1 and a difference for lamp No. 2 and these were used as coordinates to plot a point for each laboratory for this pair of lamps. Each odd numbered lamp was paired with the even numbered lamp following it and a point was plotted for each pair of lamps for each laboratory. In this way five points were plotted for each laboratory (see figure 1). The following symbols were used for the laboratories.

Sylvania
Champion
Westinghouse
General Electric
Interlectric
Duro Test

The average for each lamp is at the origin and the points plotted are differences from the average. In addition the average difference for all the odd numbered lamps for each laboratory was plotted as the x-coordinate against the average difference for all the even numbered lamps as the y-coordinate. These average differences are designated by solid symbols.

If only random errors were present in the data these 36 points would form an approximately circular cluster centered at the origin. On the other hand if the lumens measured by one laboratory on lamp No. 1 differs from the average of all the laboratories' measurement of lumens on lamp No. 1 by D L lumens and if their measurement on lamp No. 2 differs from the average on lamp No. 2 by the same amount the point representing this pair of lamps will lie on a line drawn at 45° through the origin. Consequently if the results for the lumen measurements on each lamp in the laboratory differ from the average for each lamp by about the same amount the five points will be clustered about a point not at the origin but near the 45° line. The distance of the cluster from the origin is a measure of the laboratory bias. The compactness of the cluster is a measure of the precision of the laboratory. The center of the cluster, designated by the solid symbol, in every case is near the 45° line.

The results reported for current, volts, and watts were plotted in the same way as the lumen results and are shown in figures 2, 3, and 4.

Lumens
Differences from the Averages


figure 1

Amperes
Differences from the Averages

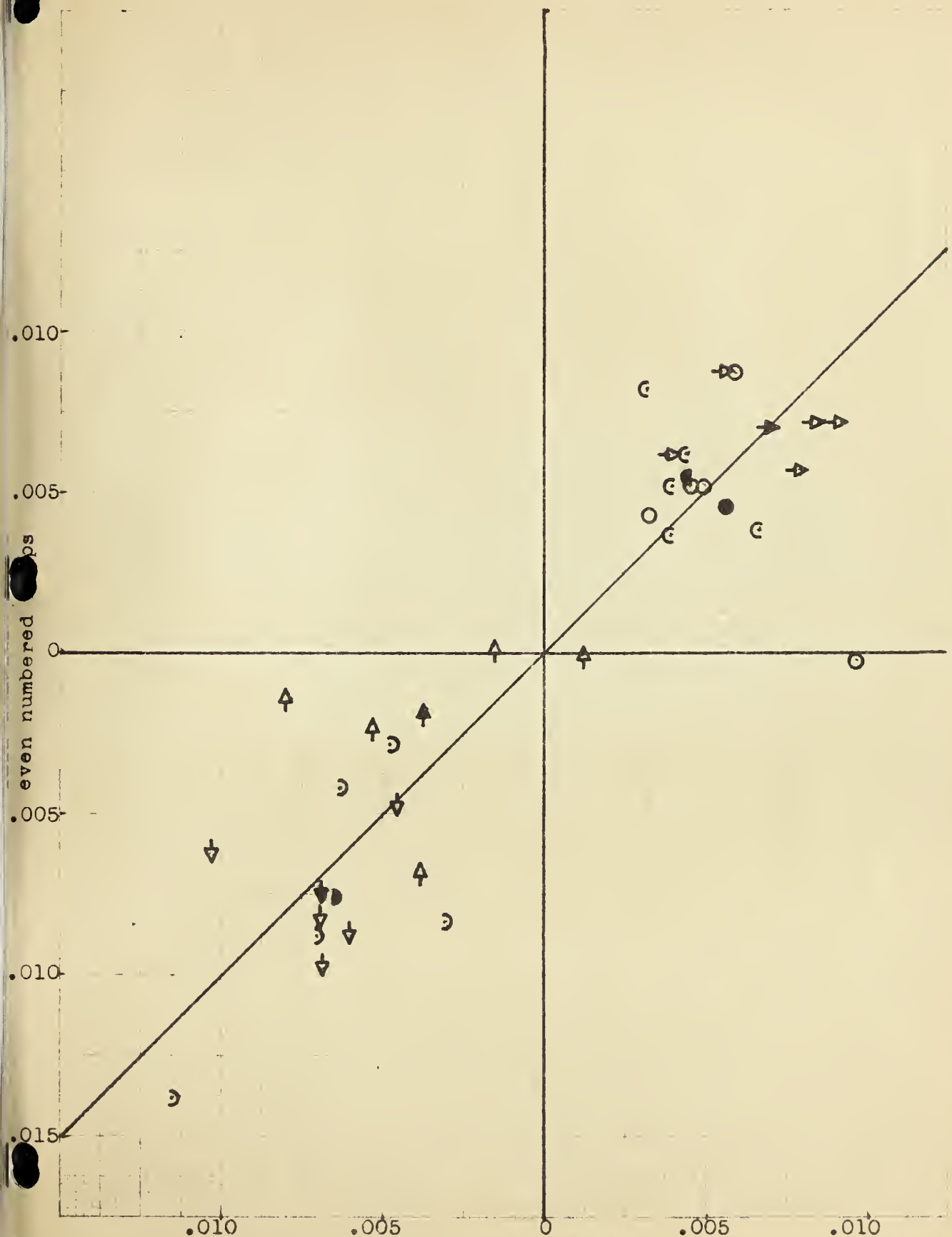


figure 2

Volts
Differences from the Averages


figure 3

Watts
Differences from the Averages


figure 4

## IV. Summary

The following table gives a summary of the measurements reported by the six laboratories.

| Quantity Measured | Average Value Reported | Range in the Averages for the 10 Lamps | Range % of Average Value | Standard Deviation of the Six Averages | Standard Deviation % of the Average of all Values Reported |
|---|---|---|---|---|---|
| Lumens | 1636.2 | 48.5 | 3 | 21 | 1.3 |
| Amperes | .4281 | .0124 | 3 | .0065 | 1.5 |
| Volts | 83.54 | 4.14 | 5 | 1.8 | 2.2 |
| Watts | 32.58 | 2.17 | 7 | .83 | 2.5 |

U.S. DEPARTMENT OF COMMERCE
Frederick H. Mueller, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

# THE NATIONAL BUREAU OF STANDARDS

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## WASHINGTON, D.C.

**Electricity and Electronics.** Resistance and Reactance. Electron Devices. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

**Optics and Metrology.** Photometry and Colorimetry. Photographic Technology. Length. Engineering Metrology.

**Heat.** Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Molecular Kinetics. Free Radicals Research.

**Atomic and Radiation Physics.** Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Radiation Theory. Radioactivity. X-rays. High Energy Radiation. Nucleonic Instrumentation. Radiological Equipment.

**Chemistry.** Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

**Mechanics.** Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

**Organic and Fibrous Materials.** Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

**Metallurgy.** Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

**Mineral Products.** Engineering Ceramics. Glass. Refractories. Enameled Metals. Constitution and Microstructure.

**Building Technology.** Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer. Concreting Materials.

**Applied Mathematics.** Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

**Data Processing Systems.** SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Application Engineering.

• Office of Basic Instrumentation.

• Office of Weights and Measures.

## BOULDER, COLORADO

**Cryogenic Engineering.** Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

**Radio Propagation Physics.** Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships. VHF Research. Radio Warning Services. Airglow and Aurora. Radio Astronomy and Arctic Propagation.

**Radio Propagation Engineering.** Data Reduction Instrumentation. Modulation Research. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation Obstacles Engineering. Radio-Meteorology. Lower Atmosphere Physics.

**Radio Standards.** High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Electronic Calibration Center. Microwave Physics. Microwave Circuit Standards.

**Radio Communication and Systems.** Low Frequency and Very Low Frequency Research. High Frequency and Very High Frequency Research. Ultra High Frequency and Super High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Systems Analysis. Field Operations.


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